Pacific Science (1990), vol. 44, no. 3: 297–310

Zooplankton of the Gulf of California after the 1982–1983 El Niño Event: Biomass Distribution and Abundance[1]

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ABSTRACT: From 23 March to 7 April 1984, we studied the responses of zooplankton populations to the 1982–1983 El Niño event in the Gulf of California. Twenty six stations were sampled for zooplankton distribution and abundance. Mean displacement volume was 388 $cm^3/1000\ m^3$, a value higher than biomass values reported for the California Current and the eastern tropical Pacific. Maximum values (up to 60 mg/m^3 of dry weight) were registered on the eastern shore of the gulf. At other stations biomass values ranged from 11.2 to 39.2 mg/m^3. No significant differences were observed in the mean biomass of the central gulf between spring 1983 and spring 1984. However, biomass increased in the southern gulf during spring 1984. Mean total abundance of zooplankton was 13% higher than in 1983. Coastal stations registered up to 31% of the total abundance. Copepods and cladocerans represented over 65% of mean total abundance and community structure differed from that in 1983: there were more copepods, euphausiids, tunicates, and siphonophores in 1984, and fewer cladocerans, ostracods, and red crabs (*Pleuroncodes planipes*). Similarity analysis showed two main assemblages: one in the central gulf (temperate zone), the other near the mouth (tropical zone). These two regions correspond to zones with different physical and primary production characteristics. The different responses seen in the central and southern gulf may reflect phytoplankton biomass and primary productivity dynamics. The El Niño event reduced the biomass in the southern part of the gulf, although the entire gulf in 1983 and 1984 showed higher biomass values than other eastern Pacific systems. Year-to-year differences may be less important than seasonal changes. The El Niño phenomenon mainly affected the relative abundances of different taxa.

THE GULF OF CALIFORNIA is a large evaporative basin, with surface salinity about >35‰. It freely connects with the Pacific Ocean. The mouth of the gulf is located in a transitional zone influenced by two large circulation systems: the equatorial system and the anticyclonic gyre of the North Pacific, with intensities varying seasonally and interannually in response to the dominant wind regimes (Wyrtki 1966, Baumgartner and Christensen 1985). The complex dynamics result in variability in production cycles and permanent instability in the distributional ranges of planktonic species (Gilbert and Allen 1943, Round 1967, Zeitszchel 1969, Brinton et al. 1986, Valdéz-Holguín and Lara-Lara 1987, Jiménez-Pérez and Lara-Lara 1988).

The pelagic ecosystem of the Gulf of California is affected by El Niño/southern oscillation events (Baumgartner and Christensen 1985, Robles-Pacheco and Marinone 1987, Valdéz-Holguín and Lara Lara 1987, Jiménez-Pérez and Lara-Lara 1988, Lara-Lara and Valdéz-Holguín 1988, Lavaniegos-Espejo et al. 1989). During El Niño periods, tropical and subtropical diatoms in the laminated sediments increase (Baumgartner et al. 1985). This enhancement of phytoplankton micro-

[1] This study was supported through project PCECBNA-021265. Ship time was awarded by the National Council of Science and Technology of México (CONACYT). Manuscript accepted October 1989.
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fossils in the central gulf may correspond to periods of increased primary productivity and chlorophyll *a* content such as were measured during the 1982–1983 El Niño event (Valdéz-Holguín and Lara-Lara 1987). High zooplankton volumes have also been reported during the El Niño event (Jiménez-Pérez and Lara-Lara 1988). This contrasts with lower phytoplankton productivity rates (Dandonneau and Donguy 1983, McGowan 1983, Chávez et al. 1984) and diminished zooplankton volumes observed in other eastern Pacific systems during El Niño events (McGowan 1984, Barber and Chávez 1986).

Our objective was to study the effects of the El Niño phenomenon on zooplankton biomass and abundance, and compare biomass distribution and abundance in spring 1984 (El Niño relaxation period) with the biomass and abundance reported in spring 1983 (at the peak of the El Niño event) for the Gulf of California.

Study area

The only evaporative basin in the Pacific Ocean is the Gulf of California (Roden 1964). It is located in an arid environment between the Baja California Peninsula and mainland Mexico (Figure 1). The gulf is about 1000 km long and about 150 km in average width. The upper gulf is separated from the lower gulf by two large midriff islands. The lower gulf comprises a series of basins (2000–3000 m deep). Strong, semicontinuous tidal mixing and seasonal upwelling occur in the central gulf, near the northern islands; northwesterly winds cause upwelling on the eastern shore during winter-spring, and southerly winds cause upwelling on the western shore in summer (Roden and Groves 1959, Badán-Dangón et al. 1985). These processes result in exceptionally high phytoplankton productivity in the gulf (Zeitzschel 1969), in contrast to productivity in the other large marginal seas of the world, the Mediterranean and the Red seas. The physicochemical environment and primary productivity are reported by Alvarez-Borrego (1983) and Alvarez-Borrego and Lara-Lara (in press).

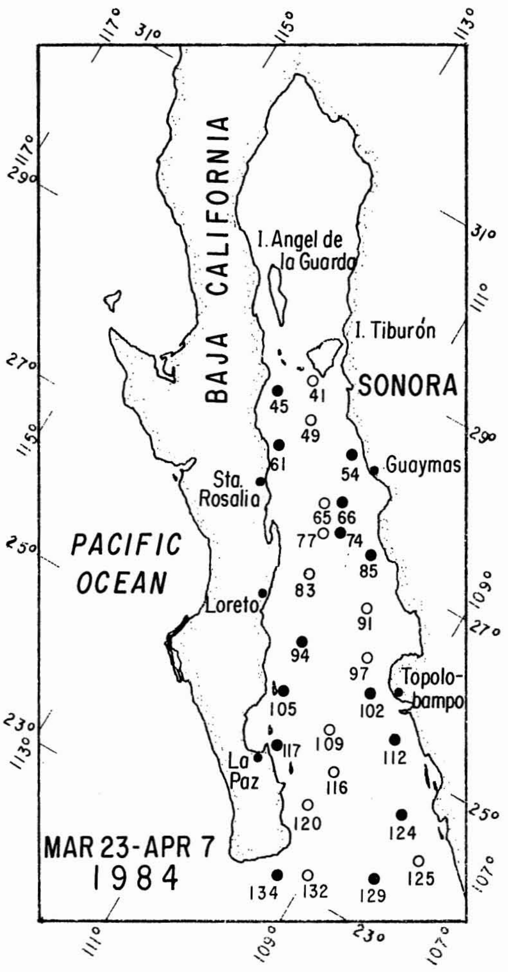

FIGURE 1. Sampling stations in the Gulf of California: o, day and •, night tows.

MATERIALS AND METHODS

Twenty-six stations were sampled from the mouth to the central gulf (Figure 1), from 23 March to 7 April 1984, aboard the R/V *El Puma*. At each station an oblique tow with a Bongo net (60 cm diam., 0.333-mm mesh size) from 200 m to the surface was performed. Water volume filtered was measured with a TKS flowmeter. Samples were collected at noon and midnight, preserved in 4% formaldehyde, and neutralized with sodium borate.

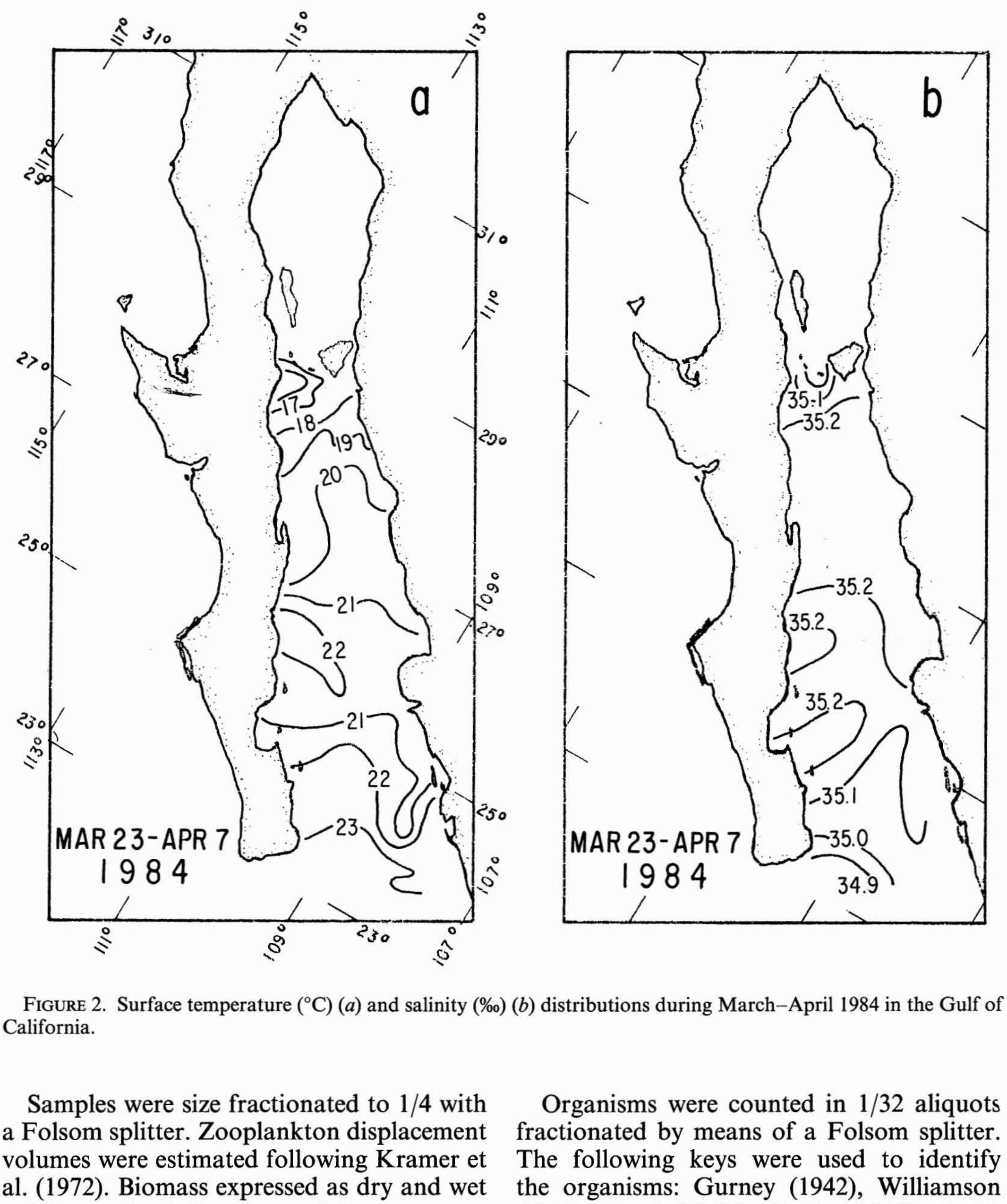

FIGURE 2. Surface temperature (°C) (*a*) and salinity (‰) (*b*) distributions during March–April 1984 in the Gulf of California.

Samples were size fractionated to 1/4 with a Folsom splitter. Zooplankton displacement volumes were estimated following Kramer et al. (1972). Biomass expressed as dry and wet weight, and ash-free dry weight were measured following Beers (1976). Biomass differences between day and night tows were tested using the Mann-Whitney test (Siegel 1980).

Kendall's correlation coefficient was used to correlate surface temperature, salinity (measured with a Bissett-Berman CTD), and zooplankton biomass.

Organisms were counted in 1/32 aliquots fractionated by means of a Folsom splitter. The following keys were used to identify the organisms: Gurney (1942), Williamson (1957), Boyd (1960), Hardy (1965), Smith (1977), and Yamaji (1977). To estimate possible combined effects of vertical migration and net avoidance, day abundances were compared with night abundances by means of the Mann-Whitney test (Siegel 1980).

Faunistic associations were assessed by estimating the similarity between stations with

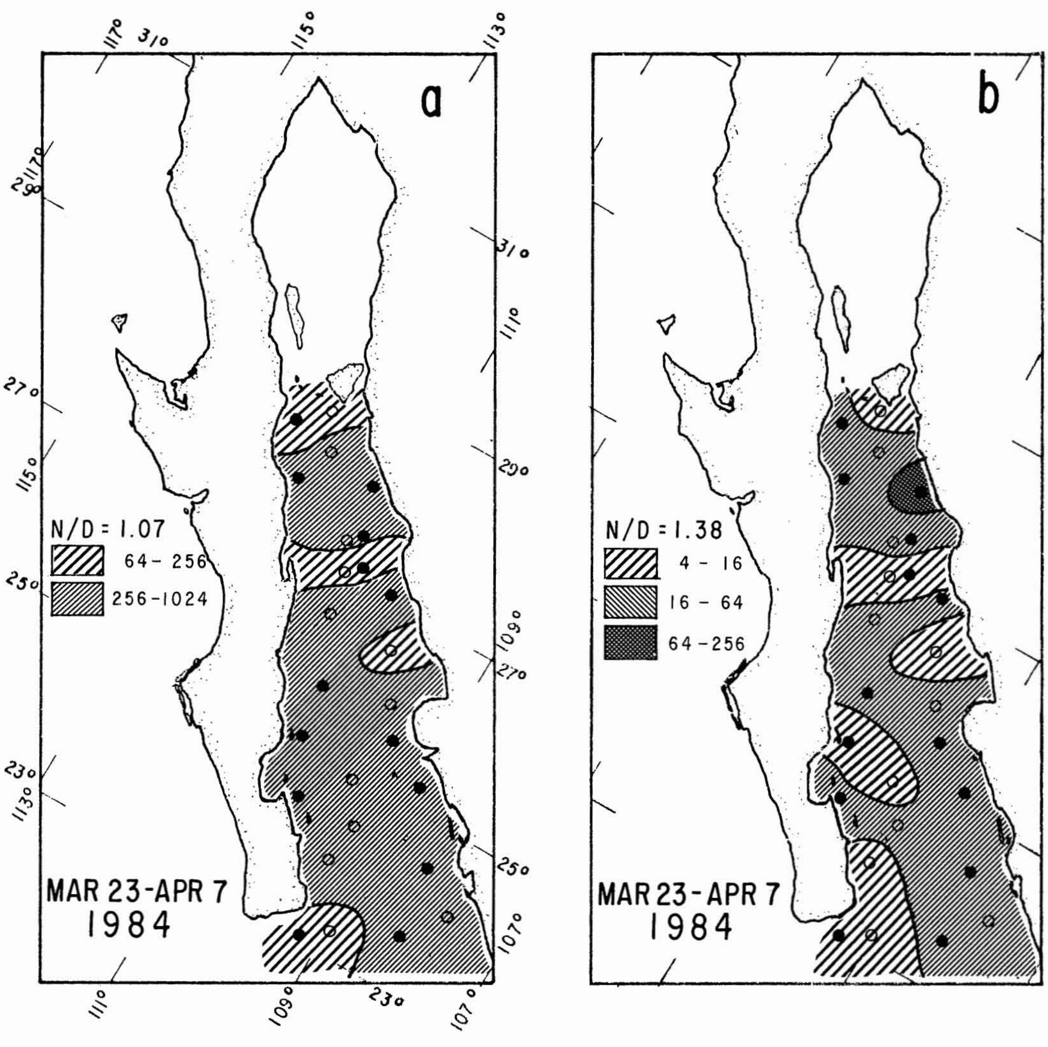

FIGURE 3. Zooplankton biomass in the Gulf of California during March–April 1984: *a*, displacement volume ($cm^3/1000\ m^3$); *b*, ash-free dry weight (mg/m^3). N/D denotes the ratio between the medians of results of night and day tows.

Kendall's correlation coefficient, followed by a grouping technique, as described by Davis (1973).

RESULTS

Surface salinity values of $>35.2‰$ were recorded for more than 50% of the sampling stations (Figure 2*b*). Only in the southern gulf and the northernmost stations was salinity equal to or less than 35.0‰.

Minimum surface temperature (15.9°C) was registered south of Ballenas channel (29° N, 113.5° W), and temperatures increased progressively to the south, reaching 23°C at the mouth of the gulf (Figure 2*a*). In the central gulf, lower temperatures were found at

TABLE 1

ZOOPLANKTON BIOMASS IN THE GULF OF CALIFORNIA DURING MARCH–APRIL 1984

	STATION	DISPLACEMENT VOLUME ($cm^3/1000\ m^3$)	WET WEIGHT ($g/1000\ m^3$)	DRY WEIGHT (mg/m^3)	ASH-FREE DRY WEIGHT (mg/m^3)
Central	41	154	141	11	8
	45	201	199	24	22
	49	607	583	32	19
	54	887	919	132	118
	66	421	409	36	32
	61	458	444	30	20
	65	491	512	31	
	74	150	156	11	9
	85	819	811	62	58
	77	166	168	14	12
$\bar{x}$		435	434	38	30
South	83	604	611	39	24
	102	261	259	25	22
	91	239	240	16	13
	97	260	259	22	18
	94	304	311	25	22
	112	603	654	62	57
	105	271	269	15	13
	109	294	298	20	16
	116	507	508	34	28
	124	350	362	20	17
	117	622	648	35	26
	120	382	393	17	14
$\bar{x}$		391	401	28	23
Mouth	125	335	319	31	26
(south of 24° N lat.)	129	322	326	22	19
	132	213	219	13	12
	134	186	209	15	13
Total	$\bar{x}$	389	393	31	25
	SD	198	203	24	23

NOTE: Stations are divided at 27° N lat. for central and south areas.

the western shore, while in the southern gulf the lowest temperatures were registered at the eastern shore.

Biomass Distribution

Zooplankton displacement volume averaged 389 $cm^3/1000\ m^3$ (150–887 $cm^3/1000\ m^3$), and the distribution was homogeneous throughout the gulf (Figure 3*a*). Values for stations on the eastern continental shelf averaged 585 $cm^3/1000\ m^3$, 60% higher than those from the other stations (Table 1). Wet weight was distributed as the displacement volume, averaging 393 $g/1000\ m^3$ (Table 1). Mean dry weight was 31 mg/m^3; 88% of the values were less than 40 mg/m^3, and only two shallow (< 100 m) stations on the eastern continental shelf showed values higher than 60 mg/m^3 (Table 1). Ash-free dry weight also showed these maxima (> 55 mg/m^3). With the exception of two stations at the mouth of the gulf, where biomass was low (Figure 3*b*), the range of biomass was from 16 to 32 mg/m^3. There were no significant differences ($P > .05$) in results from day and night tows. No significant correlations were found between biomass and surface temperature or salinity.

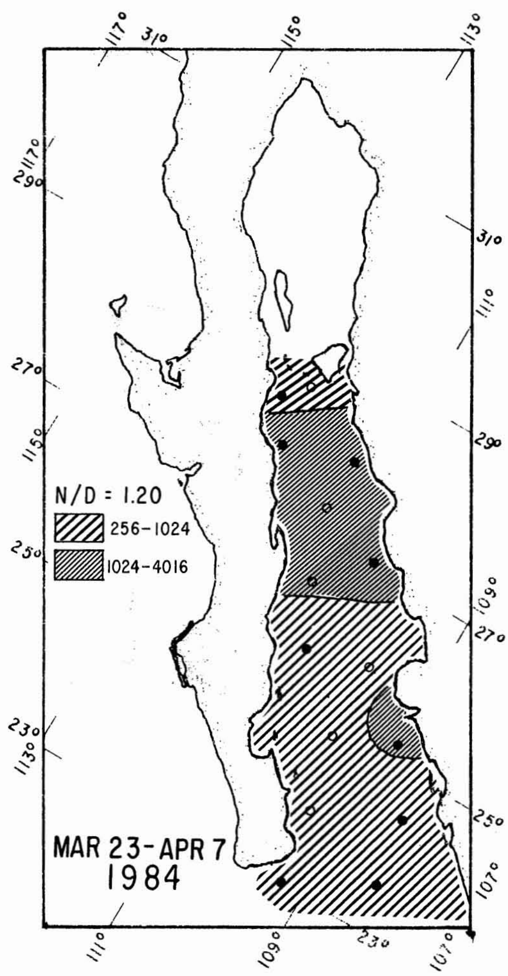

FIGURE 4. Total zooplankton abundance (ind/m^3). N/D indicates the night-to-day median ratio of results of night and day tows.

Abundance

Mean total zooplankton abundance was 1087 individuals (ind)/m^3. Maximum abundance (3321 ind/m^3) was registered in a coastal station south of 28° N (Figure 4). Other stations in the southern gulf showed lower densities (< 1000 ind/m^3) than those in the central area (Figure 4).

The zooplankton populations were divided into 29 taxonomic groups (Table 2). Holoplankton species represented 97.4%, and meroplankton 2.6% of mean abundance. Copepods reached the highest densities (560 ind/m^3), followed by cladocerans (161 ind/m^3). These two groups represented 66.3% of total zooplankton abundance by numbers (Table 3). The following eight groups: euphausiids, chaetognaths, radiolarians, siphonophores, apendicularians, veliger larvae, ostracods, and polychaetes, averaged from 10 to 79 ind/m^3 and were responsible for 29.4% of the total abundance (Table 3). Densities of the remaining groups were below 10 ind/m^3. No statistical differences ($P > .05$) were found between abundances in day and night tows. Affinity among stations was high (Table 4). Ninety-four percent of the correlation coefficients were highly significant ($P < .001$), and the remaining very significant ($.001 < P < .01$).

The affinity dendrogram (Figure 5) shows two main zooplankton assemblages (Figure 6), one in the central gulf and the other at the mouth. Comparisons between the abundances of these two assemblages showed significant ($P < .05$) differences for several zooplankton taxa: copepods, siphonophores, ctenophores, and invertebrate larvae were more abundant in the central gulf; and veliger larvae, heteropods, amphipods, and stomatopod larvae reached higher densities in the southern assemblage.

DISCUSSION

Environmental conditions in the Gulf of California in March 1983 showed climatic anomalies resulting from the El Niño event that affected the eastern Pacific Ocean between fall 1982 (Cane 1983, Rasmusson and Wallace 1983) and fall 1983. Surface salinity decreased (< 34.9‰) while surface temperature increased up to 3°C, and sea level rose to its maximum in the last 20 yr (Robles-Pacheco and Marinone 1987). During spring 1984, values for surface salinity reverted toward the more usual values reported by Roden and Groves (1959), Roden (1964), and Alvarez-Borrego and Schwartzlose (1979). Surface temperatures were 1° to 2°C lower during the spring of 1984, showing that the El Niño event had weakened.

TABLE 2

ABUNDANCES (IND/M³) OF THE MAIN ZOOPLANKTONIC GROUPS

GROUPS	SAMPLING STATIONS														
	41	45	54	61	65	85	83	97	94	112	109	124	120	129	134
COPEPODA (Sc)	124	741	475	425	535	1093	439	329	436	2382	165	264	351	379	261
CLADOCERA	1	4	4	466	812	0	256	275	31	222	268	26	2	44	1
EUPHAUSIACEA	151	46	490	36	68	136	27	4	58	152	<1	4	4	10	3
CHAETOGNATA (Ph)	4	36	25	57	69	194	102	70	34	126	24	25	43	63	24
RADIOLARIA (C)	4	2	3	96	45	3	103	57	25	9	8	24	134	108	135
SIPHONOPHORA	6	72	12	52	200	27	44	19	16	222	10	8	8	5	6
APPENDICULARIA	2	2	3	191	116	5	15	61	15	112	33	27	39	31	16
Veliger larvae	<1	<1	1	5	2	3	1	3	9	15	1	41	6	105	23
OSTRACODA (Sc)	11	25	9	16	10	6	32	13	17	8	13	8	9	16	6
POLYCHAETA (C)	1	4	3	23	24	2	38	14	11	0	9	5	4	10	7
DOLIOLIDAE	<1	2	<1	2	12	1	3	6	3	3	5	22	38	1	28
Fish eggs and larvae	<1	<1	1	5	10	1	26	9	25	5	1	3	2	11	4
FORAMINIFERA	1	<1	<1	15	22	1	17	6	1	9	<1	2	1	4	3
THECOSOMATA	<1	1	1	7	8	4	6	7	7	15	2	2	9	7	2
Echinodermata larvae	1	2	3	13	7	0	17	15	1	4	4	<1	<1	2	0
HYDROMEDUSAE (C)	<1	2	<1	2	8	2	1	1	3	12	1	1	2	2	<1
DECAPODA	<1	3	3	1	2	2	1	2	6	9	2	2	1	2	1
HETEROPODA (Sf)	<1	<1	<1	1	1	3	1	2	2	1	<1	3	4	11	1
AMPHIPODA	0	<1	1	1	<1	1	1	2	5	5	3	3	4	2	2
SALPIDAE	0	0	2	0	0	1	2	1	8	0	2	1	<1	<1	2
GYMNOSOMATA	<1	<1	<1	2	3	0	5	1	1	1	<1	1	<1	1	<1
Other invertebrate larvae	0	0	0	2	1	0	6	7	0	1	0	0	0	0	0
Cyphonautes larvae	0	1	1	<1	2	3	3	1	1	3	0	<1	<1	0	0
CTENOPHORA (Ph)	1	0	<1	0	<1	7	<1	<1	0	0	0	0	0	0	0
Cirripedia larvae	0	<1	0	0	1	0	0	<1	<1	1	<1	0	0	0	0
ISOPODA	0	0	0	0	0	0	<1	1	<1	0	<1	<1	<1	<1	<1
CEPHALOPODA	<1	0	<1	0	0	0	0	0	<1	0	0	1	0	<1	<1
SCYPHOMEDUSAE (C)	0	0	0	0	0	0	0	<1	0	0	0	0	<1	<1	0
Stomatopoda larvae	0	0	0	0	0	0	0	0	<1	<1	0	<1	<1	0	<1
Not identified	0	0	0	1	0	1	4	3	1	4	0	0	1	1	2
Total	307	943	1,037	1,419	1,958	1,496	1,150	909	716	3,321	551	473	662	815	527
%	1.9	5.8	6.4	8.7	12	9.2	7.1	5.6	4.4	20.4	3.4	2.9	4.1	5	3.2
Number of groups	21	22	24	22	24	20	25	27	26	23	23	25	25	24	23

NOTE: Names in capital letters indicate holoplankton, lower-case letters indicate groups belonging to the meroplankton. Ph denotes phylum; C, class; Sc, subclass; Sf, superfamily; others are Orders.

TABLE 3

RELATIVE (%) AND MEAN ABUNDANCE (IND/M^3) OF THE GROUPS OF ZOOPLANKTON

GROUPS	$\bar{x}$	%	% CUMULATIVE
COPEPODA (Sc)	560	51.6	51.6
CLADOCERA	161	14.8	66.4
EUPHAUSIACEA	79	7.3	73.7
CHAETOGNATA (Ph)	60	5.5	79.2
RADIOLARIA (C)	50	4.6	83.8
SIPHONOPHORA	47	4.3	88.1
APPENDICULARIA	45	4.1	92.2
Veliger larvae	14	1.3	93.6
OSTRACODA (Sc)	13	1.2	94.8
POLYCHAETA (C)	10	1.0	95.7
DOLIOLIDAE	8	0.8	96.5
Fish eggs and larvae	7	0.6	97.1
FORAMINIFERA	5	0.5	97.6
THECOSOMATA	5	0.5	98.1
Echinodermata larvae	5	0.4	98.6
HYDROMEDUSAE (C)	2	0.2	98.8
DECAPODA	2	0.2	99.0
HETEROPODA (Sf)	2	0.2	99.2
AMPHIPODA	2	0.2	99.4
SALPIDAE	1	0.1	99.5
GYMNOSOMATA	1	0.1	99.6
Other invertebrate larvae	1	0.1	99.7
Cyphonautes larvae	1	0.1	99.8
CTENOPHORA (Ph)	1	0.0	99.8
Cirripedia larvae	0	0.0	99.8
ISOPODA	0	0.0	99.8
CEPHALOPODA	0	0.0	99.9
SCYPHOMEDUSAE (C)	0	0.0	99.9
Stomatopoda larvae	0	0.0	99.9
Not identified	1	0.1	100.0
Total	1,086	100.0	100.0

NOTE: See footnote of Table 2 for explanation of abbreviations.

TABLE 4

KENDALL'S CORRELATION COEFFICIENTS MATRIX BETWEEN SAMPLING STATIONS

STATION	45	54	61	65	85	83	97	94	112	109	124	120	129	134
41	.680	.619	.677	.644	.559	.519	.542	.570	.563	.505	.483	.505	.552	.464
45		.700	.675	.743	.495	.556	.604	.650	.640	.631	.541	.579	.504	.442
54			.591	.511	.484	.514	.521	.680	.549	.610	.529	.478	.493	.437
61				.850	.413	.746	.812	.632	.664	.657	.639	.621	.644	.537
65					.418	.693	.716	.613	.670	.605	.589	.561	.539	.483
85			.010	.010		.347	.353	.509	.498	.357	.458	.570	.436	.470
83					.010		.720	.545	.480	.520	.509	.488	.501	.463
97					.010			.586	.563	.694	.628	.620	.645	.533
94									.596	.663	.713	.627	.673	.634
112										.473	.526	.528	.535	.391
109					.010						.688	.637	.604	.564
124												.742	.740	.762
120													.720	.694
129														.658
134									.010					

NOTE: P < .001, or as otherwise indicated.

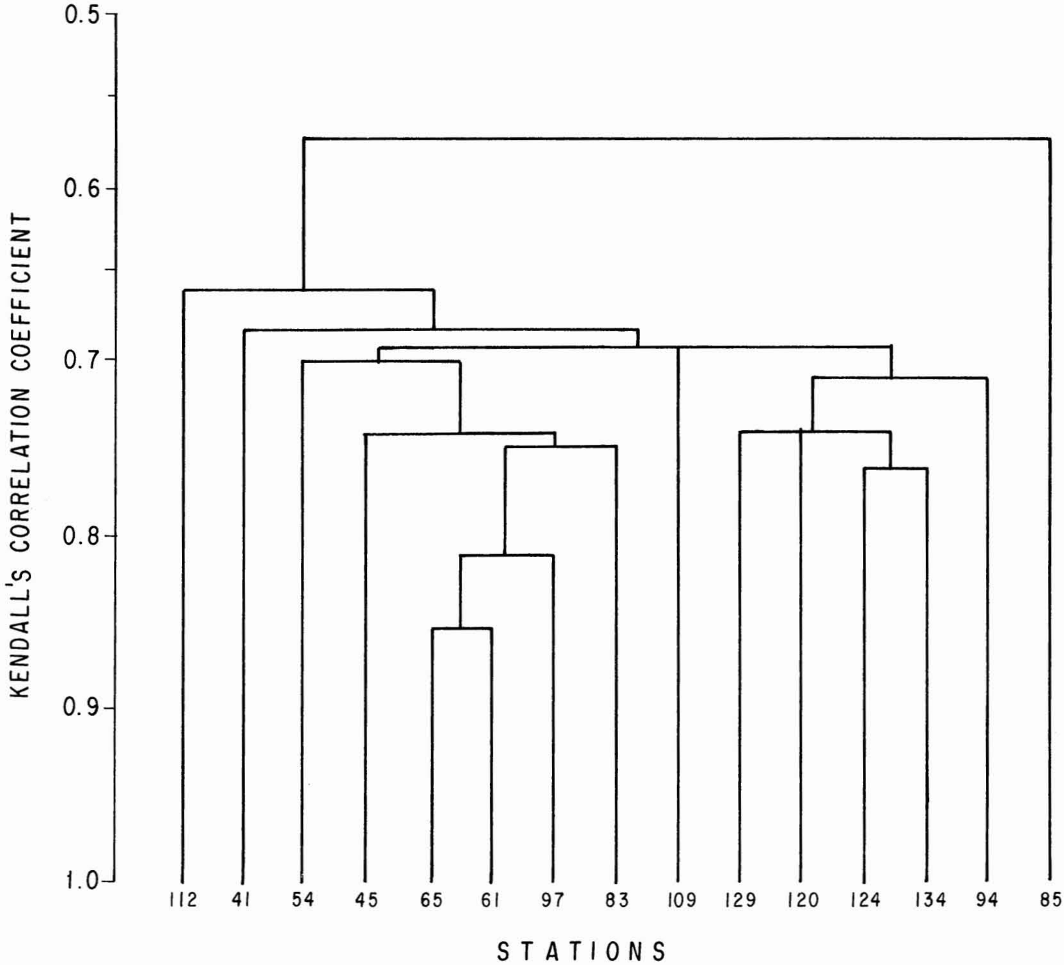

FIGURE 5. Stations affinity dendrogram based upon Kendall's correlation coefficient.

Biomass

Zooplankton biomass values during spring 1984 were similar between stations, conforming to the pattern reported for the gulf in April in the cold years of 1956 and 1957 (Brinton et al. 1986). In contrast, biomass distribution during March 1983 was more variable between stations (Jiménez-Pérez and Lara-Lara 1988), although biomass values for the central gulf were similar in spring 1983 and spring 1984. For example, Jiménez-Pérez and Lara-Lara (1988) reported 1983 mean biomass values of 532.3 $cm^3/1000\ m^3$, 454.3 mg/m^3, and 33.36 mg/m^3 for displacement volume, wet weight, and dry weight, respectively, which are similar to the values we found in 1984. In contrast, during the past El Niño event, zooplankton displacement volumes in the Perú Current (Chávez et al. 1984) and the California Current (McGowan 1984, 1985, Green-Ruíz 1986) were noticeably decreased. This different behavior between the central Gulf of California and the Perú and California currents may reflect phytoplankton availability. In the Gulf of California biomass and primary productivity were enhanced during 1983–1984 (Valdéz-Holguín and Lara-Lara 1987, Lara-Lara and Valdéz-Holguín 1988). Valdéz-Holguín and Lara-Lara (1987)

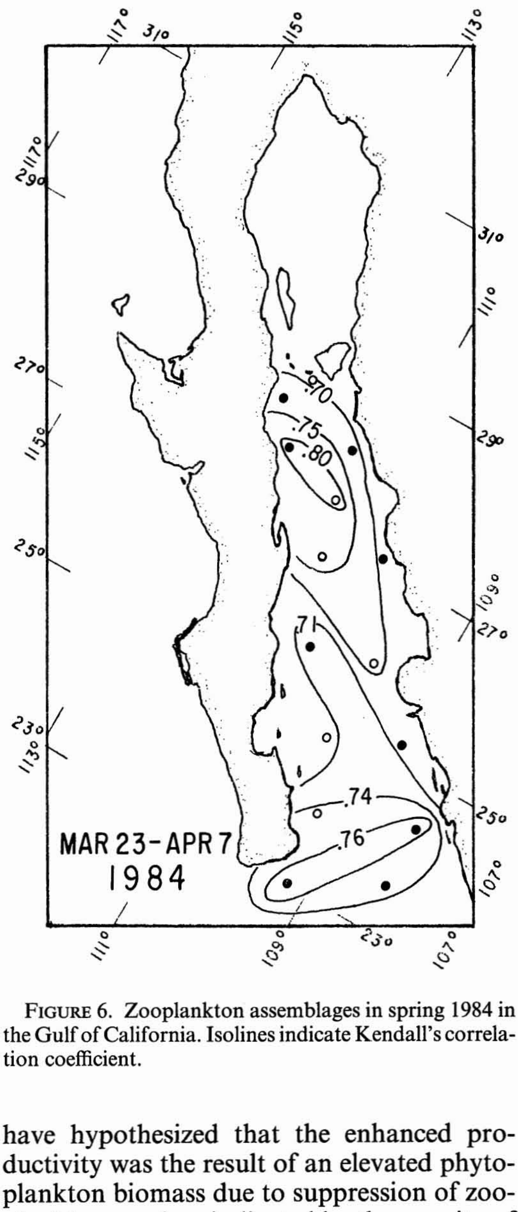

FIGURE 6. Zooplankton assemblages in spring 1984 in the Gulf of California. Isolines indicate Kendall's correlation coefficient.

have hypothesized that the enhanced productivity was the result of an elevated phytoplankton biomass due to suppression of zooplankton grazing, indicated by the scarcity of typical calanoids during spring 1983. *Oithona* sp. and *Penilia avirostris* were the dominant species in 1983 (Jiménez-Pérez and Lara-Lara 1988). In the southern gulf, Jiménez-Pérez and Lara-Lara (1988) reported mean biomass values of 209.6 $cm^3/1000\ m^3$, 148.7 mg/m^3, and 18.95 mg/m^3 for displacement volume, wet weight, and dry weight, respectively. These values are about 40% lower than the ones for 1984. This different response between the central and southern portions of the gulf may reflect the stronger influence of oceanic waters in the southern gulf. In consequence, the zooplankton biomass decreased in 1983 in the southern gulf, as reported for the Peruvian waters and the California Current. Our results indicate that the southern and central gulf are more than mere geographic limits: that the structure and function of the plankton ecosystem is indeed different in the two sections, the central gulf being more temperate and the southern more tropical-oceanic. These differences have been noted previously (Brinton el al. 1986, Valdéz-Holguín and Lara-Lara 1987, Jiménez-Pérez and Lara-Lara 1988). Biomass values (Griffiths 1968; Farfán 1973, Cummings 1977) previously reported for the Gulf of California have been in areas not comparable with our study.

There are no long-term zooplankton biomass series in the gulf that can be compared with other ecosystems to evaluate interannual variability. If we average the values for the whole gulf, interannual variability of the zooplankton biomass becomes negligible, and El Niño events seem to affect mainly the relative abundances of the zooplankton groups. However, if we average by zones (central versus south), then differences between years appear in the southern portion of the gulf. Our results show that although the southern gulf behaves as does the California Current (Thrailkill 1961, McGowan 1984, 1985, Green-Ruíz 1986) and other areas in the eastern Pacific (Flores-Zepeda 1985) during El Niño events, average zooplankton biomass in the gulf is always higher (Table 5).

Numerical Abundance

Zooplankton abundances in spring 1984 were up to 13% higher than the densities reported by Jiménez-Pérez and Lara-Lara (1988) for spring 1983. In comparison with the California Current, mean zooplankton abundance for the Gulf of California during the springs of 1983 and 1984 was an order of magnitude higher (Table 6). This may be the result of the high primary productivity and chlorophyll *a* concentrations measured dur-

TABLE 5

COMPARISONS OF ZOOPLANKTON DISPLACEMENT VOLUMES (cm³/1000 m³)

GEOGRAPHIC AREA	VOLUME (cm³/1000 m³)	DATE	DEPTH (m)	MESH WIDTH (mm)	REFERENCES
Gulf of California					
29°–24° N	405	Mar. 1983	200	0.333	Jiménez-Pérez and Lara-Lara (1988)
29°–24° N	445	Mar.–Apr. 1984	200	0.333	This study
24°–23° N	254	Mar.–Apr. 1984	200	0.333	This study
California Current					
30°–25°40′ N	255	Mar. 1951–1957	140	0.600	Staff, SPFI (1952–1956), Thrailkill (1957, 1959)
30°–25°40′ N	310	Apr. 1951–1957	140	0.600	Thrailkill (1957, 1959)
30°–25°40′ N	73	Mar. 1958	140	0.600	Thrailkill (1961)
30°–25°40′ N	88	Apr. 1958	140	0.600	Thrailkill (1961)
25°35′–23°26′ N	65	Dec. 1982	200	0.505	Green-Ruiz (1986)
25°35′–23°26′ N	86	Feb. 1983	200	0.505	Green-Ruiz (1986)
25°35′–23°26′ N	20	May 1983	200	0.505	Green-Ruiz (1986)
North Equatorial Current (20°–10° N)					
Oceanic zone	75	Oct. 1955	300	0.600	Holmes et al. (1957)
Dome of Costa Rica	272	Dec. 1955	300	0.600	Holmes et al. (1957)
Dome of Costa Rica	161	Nov. 1982	200	0.333	Flores-Zepeda (1985)
Dome of Costa Rica	181	Nov. 1982	200	0.505	Flores-Zepeda (1985)
North Equatorial Countercurrent (10°–4° N)					
Oceanic zone	113	Oct. 1955	300	0.600	Holmes et al. (1957)
Dome of Costa Rica	165	Nov. 1955	300	0.600	Holmes et al. (1957)
Dome of Costa Rica	143	Nov. 1982	200	0.333	Flores-Zepeda (1985)
Dome of Costa Rica	135	Nov. 1982	200	0.505	Flores-Zepeda (1985)
South Equatorial Current (4° N–4° S)					
Oceanic zone	1,215	Nov.–Dec. 1955	300	0.600	Holmes et al. (1957)
Coastal zone	323	Nov. 1955	300	0.600	Holmes et al. (1957)

NOTE: We estimated the averages, using only data from night tows. All tows were oblique.

ing this period as previously discussed. The zooplankton populations were dominated by copepods, but they only represented about 51% of the total abundance in 1984 and 44% in 1983. In the California Current system, copepods have been reported to represent up to 70% of total zooplankton abundance (Table 6). This is the result of the considerable contribution by the cladocerans to the total abundance in the gulf, 14% in 1984 and 30% in 1983. The most abundant cladoceran, *Penilia avirostris*, which is characteristic of tropical coastal waters, inhabits temperate central gulf waters (Jiménez-Pérez and Lara-Lara 1988). Abundance of these two groups, copepods and cladocerans, showed an inverse behavior from 1983 to 1984; abundance of copepods increased and that of cladocerans decreased. Other differences in abundance between the springs of 1983 and 1984 were shown by the other groups (abundances in the range of 10–100 ind/m³): abundance of euphausiids, tunicates, and siphonophores increased in 1984, and that of ostracod and red crab (*Pleuroncodes planipes*) decreased in 1984 (Table 6).

Total numerical abundance distribution and the station affinity analysis showed the presence of two large assemblages: (1) the warm temperate in the central gulf, where tidal mixing and upwelling are common and cause the cool water in this area (Badán-Dangón el al. 1985); and (2) the tropical one in the southern gulf (stations south of 27° N) with more equatorial influence. In spring 1983, these two main asemblages were also shown for copepod species (Jiménez-Pérez and Lara-Lara 1988).

We have presented here more evidence that shows that the semienclosed ecosystem of the

TABLE 6

COMPARISONS OF MEAN ABUNDANCES (IND/M^3) OF THE MAIN TAXONOMIC GROUPS IN THE GULF OF CALIFORNIA WITH THOSE OF THE CALIFORNIA CURRENT

	Gulf of California (24°–29° N)		California Current (26°–30° N)
SAMPLING CHARACTERISTICS	Bongo net, oblique tow, 0–200 m, 0.60 m diam., 0.333-mm mesh width		Calif. Coop. Oceanic Fish Invest. net, oblique tow, 0–140 m, 1-m diam., 0.600-mm mesh width
DATE	Mar. 1983	Mar.–Apr. 1984[a]	Feb. 1959
NUMBER OF SAMPLES	5	5	5
COPEPODA	321	468	18
CLADOCERA	257	106	
EUPHAUSIACEA	11	127	2
CHAETOGNATA	58	35	2
RADIOLARIA		30	
TUNICATA	12	56	<1
SIPHONOPHORA	15	32	<1
GASTROPODA		17	11
OSTRACODA	62	15	<1
Fish eggs and larvae	2	7	<1
FORAMINIFERA		4	
HYDROMEDUSAE	2	2	<1
Pleuroncodes larvae	25	2	2
AMPHIPODA	4	2	<1
Others	21	17	<1
Total Mean Abundance	790	920	35
REFERENCES	Jiménez-Pérez (1987)	This study	Ahlstrom and Thrailkill (1963)

NOTE: We estimated the averages, using only data from night tows. All tows were oblique. See footnote of Table 2 for explanation of capital letters.
[a] Coastal stations were excluded.

Gulf of California responds differently than the typical upwelling ecosystems (California and Perú currents) to the El Niño/southern oscillation phenomenon.

ACKNOWLEDGMENTS

We thank L. C. Jiménez-Pérez for his support during collection of the samples.

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